

Standards for Distributed Modeling and Simulation

- Contact point: Dennis A. Ludwig
- Dennis.ludwig@wpafb.af.mil

Standards for Virtual Distributed Simulations: Objectives

- To provide basic definitions of terms used in the distributed simulation field
- To present an overview of standards used and needed in the distributed virtual simulation environment
- To provide references on where to go to get more information
- To generate discussion and get feedback

0.0 Standards types

- A de jure standard is a well documented convention, created by a formal standards organization. De jure means “according to law, or by right.”
- A de facto standard is a convention in common use, but not backed by any formal agreement.
- Open (i.e. Openflight)
- Proprietary (i.e. GIF)

0.1 Standards Organizations

- American National Standards Institute (ANSI)
- Electronic Industries Association (EIA)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Electrotechnical Commission (IEC)
<http://www.iec.ch>
- International Society of Automotive Engineers (SAE) <http://www.sae.org>

0.2 Standards Organizations

- International Organization for Standardization (ISO) <http://www.iso.ch>
- National Information Display Laboratory (NIDL)
- Object Management Group <http://www.omg.org>
- Telecommunications Industry Association (TIA) <http://tiaonline.org>
- Personal Computer Memory Card International Association (PCMCIA) <http://www.pcmcia.org>

0.3 Standards Organizations

- Simulation Interoperability Standards Organization (SISO) <http://www.sisostds.org>
- Society for Information display (SID) <http://www.sid.org>
- VITA <http://www.vita.com>
- Video Electronics Standards Association (VESA) <http://www.vesa.org>
- <http://www.thinkstandards.net>

0.4 Model Definitions

Model:

- A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. (DoD M&S Glossary)
- An approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system. (IEEE Standard Glossary of Modeling and Simulation Terminology, IEEE Std 6103-1989)
- A set of assumptions about how a system works, usually in the form of mathematical or logical relationships (Law, pg5)

0.5 Definitions

- System – A collection of components organized to accomplish a specific function or set of functions.
- Simulation – A method for implementing a model over time.
- DMSO online glossary:
<https://www.dmsso.mil/public/resources/glossary>
- IEEE Standard Glossary of Modeling and Simulation Terminology is IEEE Std 610.3-1989

0.6 Military Simulation Definitions

- Constructive Model or Simulation – Models and simulations that involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations, but are not involved in determining outcomes.
- Virtual Simulation – A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop in a central role by exercising motor control skills, decision skills, or communication skills.
- Live Simulation – A simulation involving real people operating real systems.

0.7 Standards for Virtual Distributed Simulations: System

First, consider the components of a distributed simulator:

1. Hardware
2. Operating system
3. Application program in some high level language
4. Middleware for distributed support
5. Model Graphics
6. Network infrastructure
7. Communications protocol
8. VV&A and Security

1. Hardware Considerations

- Any hardware platform should do given enough memory and I/O speed.
- Some serial port connectors are DB9 Male and some are DB25 Male.
- Peripheral Component Interconnect (PCI) bus for connecting peripherals (hard disks, sound cards)
- Universal Serial Bus (USB) for printers, cameras
- IEEE 1284 for parallel port, and EIA RS 232-C for serial port
- Display technology is standardized by the Video Electronics Standards Association (VESA)
- Graphics cards are either nVidia or ATI.

2.0 Operating Systems

There are many operating systems available:

- DOS
- Windows
- UNIX
- VMS
- Linux
- Oberon
- Many others
- But are there standards? (IEEE POSIX 1003.1)

2.1 An Operating System Standard?

Linux has many different distributors:

- Red Hat
- SuSE
- Mandrake
- Debian GNU/Linux
- Slackware
- FreeBSD
- Caldera
- Yellow Dog

2.2 Windows

- Windows 95
- Windows 98
- Windows 2000
- Windows XP
- Longhorn????

3.0 High Level Language Considerations

- Ada
- FORTRAN
- Pascal
- C
- C++
- Java
- Oberon
- Modula 2
- Smalltalk
- Delphi
- Many others

3.1 C language Standard

- Pre-standard language reference is “The C Programming Language,” by Brian Kernighan and Dennis Ritchie, 1978 (termed K&R C)
- American National Standards Institute (ANSI) X3.159-1989 became “ANSI C.”
- C99 adopted by ISO in 1999 and ANSI in 2000 added a new integer type.

3.2 C++ Language Standard?

C++ became an ISO/ANSI standard in 1998

- Microsoft C++
- Borland C++
- Sematech C++
- Visual C++
- Many other versions that don't follow, or will make additions to the standard

3.3 Java Language Considerations

- Java is could be considered to be a de facto standard.
- 1995 Java 1.0
- 1997 Java 1.1
- 1998 Java 2
- Real time working group

3.4 Ada Language Considerations

- Ada (MIL-STD-1815A) – the reference manual for Ada 83 was adopted by the American National Standards Institute (ANSI) in January 1983, and by the ISO in 1987.
- Revised in 1995, the ISO adopted the revised standard in February 1995, and ANSI in April 1995
- Latest revision in 2005
- Well documented, powerful language
- Not well known
- <http://www.acm.org/sigada/>

3.5 Scripting languages

- Perl
- Ruby <http://www.ruby-lang.org>
- Javascript
- Lua <http://www.lua.org>
- Java <http://java.sun.com>
- Python
- TCL

Note: Simulations and games generally use two or more types of languages.

3.6 Methodology (software engineering)

- Methodology is codified set of practices that may be repeatedly carried out to produce software (wikipedia)
- Structured
- Object Oriented

3.7 Simulation Application Program

- Typically a game engine or tool
- Extensible Architecture for Analysis and Generation of Linked Simulations (EAAGLES), formally Enhanced Air-to-air and Air-to-Ground Linked Environment Simulation.
- Torque Game Engine
- Epic Games Unreal Engine (America's Army)
- Gamebryo, by Emergent Game Technologies (Navy's 24 Blue)
- Delta3D, for small games
- Most game engines are tuned to solve a particular problem, like flight simulation, choosing a standard is not possible.

4.0 Distributed Technology

- Distributed computing Environment (DCE) by www.opengroup.org formally the OpenSystems foundation (OSF)
- ORBexpress <http://www.ois.com>
- Common Object Request Broker Architecture (CORBA) by the Object Management Group
- COM/DCOM (Distributed Component Object Model) from Microsoft
- Java Remote Method Invocation (RMI) from Sun
- Remote Procedure Call (RPC)
- Ada 95 Distributed Annex
- Jini Protocols (<http://jini.org>)

4.1 Distributed Simulation

In a distributed system, the processors do not share memory or a clock. Each processor has its own local memory.

4.2 Distributed Simulation Challenges

- Timing
- Registration, or consistency
- Movement between different worlds
- Allow users to exchange objects
- Scalability

4.3 Distributed Space

- Terrain database servers
- Synchronization
- Correlation

4.4 Distributed Time

- Distributed Synthetic Environments need a shared sense of time
- Maintain order and realism
- Global Positioning System
- Network Time Protocol
- International Earth Rotation Service (IERS)

<http://www.iers.org>

4.5 Distribution Management

- The most widely used distribution management technology is CORBA, or Common Object Request Broker Architecture
- Windows Distributed Component Object Model (DCOM); a protocol that enables software components to communicate directly over a network
- Java Remote Method Invocation (RMI)
- Proprietary, or in house methods

4.6 Distributed Correlation

- Terrain Databases
 - Different methodologies for representation leads to inconsistencies
 - Common data interchange format being evaluated (SEDRIS) (<http://www.sedris.org>)
- Sensor databases
- Behavior Correlation
 - Between computer generated forces (CGF) and manned simulators
 - Between different CGF systems

4.7 Distributed Interactive Simulation (DIS)

- IEEE Std 1278-1993 : IEEE Standard for Information Technology – Protocols for Distributed Interactive Simulation Applications
- IEEE Std 1278.1a-1998 : IEEE Standard for Distributed Interactive Simulation – Application Protocols
- IEEE Std 1278.2-1995 : IEEE Standard for Distributed Interactive Simulation – Communication Services and Profiles
- There is also a 1278.3 and 1278.4

4.8 Distributed Interactive Simulation

- DIS was based on the concept of common Protocol Data Units (PDUs)
- Full PDU object data string
- Real time only
- Full broadcast distribution (takes a lot of bandwidth) or Multicast
- When you query for information about one object, you get all available information and have to sort for what you want

4.9 IEEE Standards for HLA

- IEEE Std 1516-2000 : IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Framework and Rules
- IEEE Std 1516.1-2000 : IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Federate Interface Specification

4.10 IEEE Standards for HLA

- IEEE Std 1516.2-2000 : IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Object Model Template (OMT) Specification
- IEEE Std 1516.3-2003 : IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FDEP)

4.11 Federation and Federate Terms

- Federation - The combined simulation system created from individual simulations
- Federate - Each simulation that is combined to form a federation
- So, a federate is a member of a federation

4.12 Object Models

- An HLA object is an entity in the domain being simulated
- Object Model - A system specification defined primarily by class characteristics and relationships
- Simulation Object Model (SOM) - A specification of the types of information that an individual federate could provide to HLA federations as well as the information that an individual federate can receive from other federates in HLA federations

4.13 Three Parts of HLA Standard

- HLA rules:
 - Are a set of rules which must be followed to achieve proper interaction of simulations in a federation
 - The rules describe the responsibilities of simulations and of the runtime infrastructure in HLA federations
- Object Model Template - provides the prescribed common method for recording the information contained in the required Object Model for each federation
- Interface Specification - describes the interface functions between federates and the Runtime Infrastructure

4.14 Five Federation Rules

- Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT)
- In a federation, all representation of objects in the Federation Object Model (FOM) shall be in the federates, not in the runtime infrastructure (RTI)
- During a federation execution, all exchange of (FOM) data among federates shall occur via the RTI
- During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification
- During a federation execution, an attribute of an instance of an object shall be owned by, at most, one federate at any given time

4.15 Five Federate Rules

- Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT)
- Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM
- Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM
- Federates shall be able to vary the conditions (e.g. thresholds) under which they provide updates of attributes of objects, as specified in their SOM
- Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation

4.16 An HLA Federation

- A federation contains:
 - The Runtime Infrastructure (RTI)
 - A common object model for the data exchanged between the federates in a federation (Federation Object Model, or FOM)
 - Some number of federates
- The FOM is a description of the kinds of data and the relationships among the data that the federates will exchange

4.17 Federation Execution Development Process (FEDP)

- Define Federation Requirements
- Develop Federation Conceptual Model
- Design and Develop Federation
- Integrate and Test Federation
- Execute federation and Analyze Execution Results

4.18 Runtime Infrastructure (RTI)

- No longer freely available from DMSO
- Can get a copy from
<http://www.cc.gatech.edu/computing/pads/fdk.html>
- Purpose is to provide one architecture and one interface specification for all distributed simulations

5.0 Terrain Model Graphics

- WGS-84 (World geodetic System, 1984)
- Universal Transverse Mercator (UTM) Grid
- World Geodetic System
- Topocentric, or Flat Earth
- Universal Polar Stereographic Grid
- Geocentric
- International Terrestrial Reference Frame (ITRF)
by International Earth Rotation Service
- National Imagery and Mapping Agency
(<http://www.nima.mil>)

5.1 Terrain Data

- Digital Terrain Elevation Data (DTED)
- Shape files
- Openflight
- Creator Modeling tool
- Geotiff imagery format
- Boeing material classification standard

5.2 Graphic File Formats

- PNG
- GIF (Graphical Interchange Format)
- BMP
- TGA
- PCX
- JPEG (Joint Photographic Experts Group)
- MPEG (Moving Picture Experts Group)

5.3 Data Compression

- JPEG
- “Joint” in JPEG stands for a joint ISO/ITU effort. (Peterson)

5.4 Graphics Application Programming Interface

- Direct 3D
- OpenGL
 - <http://www.opengl.org>
- Mesa
 - <http://www.mesa3d.org>

5.5 Shading Language

- High Level Shading Language (HLSL) introduced with DirectX 9.0
- Cg language developed by NVIDIA
- “Graphics programming has evolved from a skill involving the use of operating system display routines to a bona-fide development language designed to run on its own set of unique hardware.” Snook, Greg, “Real-Time 3D Terrain Engines using C++ and Direct X9,” 2003.

5.6 Synthetic Environment Data Representation Interchange Specification (SEDRIIS)

- Purpose: to solve the M&S system environmental data interchange problem
- A method (a language) for unambiguously describing the environment, both real and simulated
- A mechanism to share and interchange the described environment
- <http://www.sedris.org>

5.7 SEDRIS

- Synthetic environment:
 - Terrain, terrain features (both natural and man-made)
 - 3-D models of vehicles, personnel,
 - The ocean, on and below the surface
 - The atmosphere
- Representational polymorphism is the capability to provide multiple representational data sets for the same synthetic environment object within a SEDRIS transmittal (I.e. as polygon structure or as a point feature)

5.8 Joint Technical Architecture (JTA)

- Specifies a set of performance based standards which are primarily commercial
- Identifies system services, interfaces, standards, and their relationships
- High Level Architecture (HLA) is in compliance with JTA
- Synthetic Environment Data Representation and Interchange Specification (SEDRIIS) is in compliance with JTA
- Common Object Request Broker Architecture (CORBA) is in compliance with the JTA

5.9 Implementing JTA

- The tool for implementing the JTA is DoD Information Technology Standards and Profile Registry (DISR)
- Mandated for the management, development, and acquisition of new or improved IT systems throughout DoD
- <http://disronline.disa.mil/>

5.10 Common Operating Environment

- Compliance with the Defense Information Infrastructure (DII) Common Operating Environment (COE) is mandated in JTA Section 1 for Command and Control, Combat Support, and intelligence systems
- Defense Information systems Agency (DISA)
- <http://diicoe.disa.mil/coe/>

5.11 Test and Training Enabling Architecture (TENA)

- <https://www.tena-sda.org> see the Architecture Reference document in the public area.
- Based on the Extended C4ISR Architecture Framework
- The Joint Technical Architecture references and advocates certain other commercial and government standards. (page 34)
- HLA is one part of TENA
- Range community standards body

5.12 Rendering standards

- OpenGL (de facto standard)
- Mesa
- Direct3D

6.0 Network Infrastructure

1. Architecture – ISO and Internet
2. Topology
3. Technologies
4. Security – encryption

6.1 Network Architecture

- Two main Internet Protocols (IP)
 - Transmission Control Protocol (TCP)
 - User Datagram Protocol (UDP)
- Others, but UDP is most often used for virtual simulations
- Internet Engineering Task Force (IETF) is responsible for protocol standards
- <http://www.ietf.org>

6.2 Network Topology

- Point to point link
- Bus (Ethernet)
- Star (hub and spoke)
- Mesh
- Ring

Hub and spoke is de facto standard.

6.3 Network Technologies

1. Ethernet, IEEE 802.3
2. Asynchronous Transfer Mode (ATM)

6.4 Network security

- Three main types of algorithms
 - Secret key algorithm
 - Public key algorithm (RSA)
 - Hashing or Message Digest algorithm (MD5)
- Data Encryption Standard (DES), secret key
- International Data Encryption Algorithm (IDEA), secret key
- Encryptors

6.5 Data Interchange Technologies

- Most common data interchange mechanism is the Ethernet
- IEEE 802.3 standard
- <http://www.ethermanage.com/ethernet/ethernet.html>
- Also may use ATM

6.6 Data Interchange, Endian

- Big endian, most significant bit of a word is in the byte with the lowest address.
- Little Endian, most significant bit of a word is in the byte with the highest address.
- Motorola, Sun Sparc, IBM Power PC – Big Endian
- Intel 80X86, DEC - Little Endian
- The TCP/IP standard network byte order is big endian
- For Ethernet, byte order is big endian, but bit transmission order for each byte is little endian

7.0 Distributed Simulation of Communications

- ASTi <http://www.asti-usa.com/products.html>
- US Navy Battle Fleet Tactical Trainer (BFTT) DIS radio/intercom?
- eMDee technology, Inc.
<http://www.emdee.com/index.jsp>
- DIS Intercom PDUs
- SimPhonics, at <http://simphonics.com>

8.0 VV&A

- Verification, Validation, and Accreditation (VV&A) is not the same as IV&V (independent verification and validation)
- IEEE Std 1278.4-1997, IEEE Trial-Use Recommended Practice for Distributed Interactive Simulation – Verification, Validation, and Accreditation
- <http://vva.dmso.mil> has a Recommended Practice Guide for VV&A

8.1 Security

- ISO/IEC standard 15408 – Common Criteria, for computer security
- <http://www.nsa.gov/ia/>
- Standards for Efficient cryptography Group (SECG) <http://www.secg.org>

Military M&S Organizations

- Defense Modeling and Simulation Office (DMSO)
- Air Force Agency for Modeling and Simulation (AFAMS)
- Army Modeling & Simulation Resource Repository (MSSR)
- Navy M&S Resources
<http://nmso.navy.mil/resources.cfm>

How can Standards be applied to M&S?

1. They have to be developed before they become obsolete.
2. They should be adaptable
3. The users have to agree to use them.
4. They have to be taught
5. Must be updated, but how often?